

Hoover Cleaning Effectiveness Testing At Reduced Suction

25 April to 13 May 2005

Report No. A05-05-001



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Test Report A05-05-001

Provided For:

The Hoover Company
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North Canton, OH 44720

General:

This test program was established to conduct comparison testing of the cleaning ability between six separate upright vacuum cleaner models. Four of the models tested were samples from a previous test conducted in February 2005, while two were new models not previously tested. Two of the previously-tested vacuum cleaner models were modified to operate at a reduced performance level. For the purpose of this test report, the models of all vacuum cleaners have been coded. Testing was conducted at The Hoover Company in North Canton, Ohio between 25 April 2005 and 13 May 2005. Testing was witnessed by Compliance Consulting Inc.

Testing followed the procedure in ASTM Standard F608, Evaluation of Carpet Embedded Dirt Removal Effectiveness of Household/Commercial Vacuum Cleaners, with the following differences. The test was intended to evaluate the cleaning effectiveness of the vacuum cleaners with a partially-filled dust receptacle. The filled receptacle condition was determined using a proposed test method for IEC 60312 - Vacuum cleaners for household use - Methods of measuring the performance. The procedure is detailed in the attached document, 59F/147/CD - IEC 60312 Ed. 4.0: Vacuum cleaners for household use - Methods of measuring the performance - Reduction in maximum air flow with partly filled dust receptacle.

Reduction in air flow was applied only to two vacuum cleaner models of one manufacturer, represented as Units 3 and 4. The other manufacturer's models, represented as Units 1 and 2, are advertised as losing no suction as a result of filling the dust receptacle. Once the reduced suction was determined for Units 3 and 4, a throttle (restrictor plate) was installed at the motor inlet to reduce the suction to the specified value, in accordance with the IEC procedure. With the reduced suction set, the cleaning effectiveness test was conducted following ASTM F608.

A general comment must be made regarding the statistics provided in F608. The precision and bias statements in F608 were determined with, and for, vacuum cleaner models in a new condition. The applicability of these precision and bias values for vacuum cleaners operating at reduced suction is not known at this time. Because of this unknown factor, the manufacturer made the decision to simply include the same Unit 3 and Unit 4 samples used during an earlier Cleaning Effectiveness test, regardless of whether or not the 90% confidence level was achieved.

Test Samples:

Six separate model vacuum cleaners were tested. A minimum of three samples of each model were evaluated (See sample chart below). Unit 1, 2, 3 and 4 samples were samples used in a recent Cleaning Effectiveness test. Unit 5 samples were new purchased samples. Unit 6 samples were provided by The Hoover Company in their original, unopened condition. Because of problems encountered trying to achieve 90% confidence for Sample 1, three additional units were purchased.

Samples Tested:

Unit 1 – Samples A³, B³, C³, D³, E³, F, G, H
 Unit 2 – Samples A, B⁹, C, D, E
 Unit 3 – Samples A, B², C, D
 Unit 4 – Samples A, B¹, C, D
 Unit 5⁴ – Samples A⁵, B⁶, C, D, E⁷
 Unit 6 – Samples A, B, C, D⁸

Notes:

- 1 - Due to proximity of serial numbers, unit not used for earlier test. This unit replaced with unit 4D.
- 2 - Used for shag carpet only; needed to reach 90% confidence in earlier test.
- 3 - 90% unable to be achieved even after running eight units. As a result, units A through E discarded. Units F through H provide the highest results.
- 4 - Nozzle brush not operated during run-in due to heating of agitator bearings after approximately 10 minutes; tended to cause chattering in nozzle.
- 5 - Nozzle motor would randomly cutout momentarily (< ½ second) during testing. This did not appear to have any impact upon the results.
- 6 - Unit discarded after two test runs due to poor performance caused by missing seal in bottom plate. Unit returned to vendor and replaced with Unit D.
- 7 - Used for shag carpet only.
- 8 - Used on shag and multi-level carpet.
- 9 - This sample was removed due to wide variations from results obtained during previous testing.

Carpets Tested:

ASTM Plush -	08/2001
ASTM Multi-Level -	09/1992
ASTM Shag -	10/2004
ASTM Level Loop -	01/2005

Test carpets used were standard ASTM carpet panels manufactured in accordance with ASTM F655-03, Standard Specification for Test Carpets and Pads for Vacuum Cleaner Testing. The level loop and shag carpets were new carpets approved for use beginning in January 2005, in accordance with ASTM Subcommittee F11.21 meeting held during the October 2004 meeting of ASTM Committee F-11 for Vacuum Cleaners.

Equipment List:

Item	Manufacturer	Model Number	Serial Number	Cal Date	Cal Due
Power Analyzer	Yokogawa	WT-200	PT-11.070 ¹	2-19-04	2-19-05
	Yokogawa	WT-200	CP-11.058 ²	1-7-05	1-7-06
Power Source	California Instruments	3000ix	N/A	7-16-04	7-16-05
Scale	Acculab	600	23390094	8-31-04	8-31-05
	Mettler	PE-16	E48897	8-31-04	8-31-05
T/H Recorder	Dickson	TH 8	CP-25.110	2-3-05	2-3-06
Stopwatch	Sportline	Alpha 410	Multiple	N/A ³	N/A
°F Psychrometer	Cole-Palmer	3312-20	N/A	N/A	N/A
Barometer	L. Black Co	N/A	M-24.20	N/A	N/A
Embedding Tool	Custom built	35 lb. w/handle	N/A	N/A	N/A

Notes:

1 - Used through 17 February 2005

2 - Used after 17 February 2005

3 - Equipment Number PT-22.205 calibrated 4-26-04 (Used to check other stopwatches)

Test sample preparation:

Upon assembly, each new sample was pre-conditioned at rated voltage and rated frequency (120 V, 60 Hz) for a period of one hour. All samples were maintained in a test area that is environmentally controlled, and locked during off hours.

Conditioning of the sample vacuum cleaners included a two-minute run-in period prior to testing, and again if not tested within a one-hour period. Test carpets were pre-conditioned each day and "topped off" if not used within a one-hour period. During the test series, two periods of carpet calibration were required. Carpet pre-conditioning records are attached.

Some models employ a belt material that has been shown to be susceptible to the effects of talc. The manufacturer has an internal laboratory practice to replace the drive belt on any model, whether the manufacturer's or competitor's, before each set of test runs (four carpets) when testing shows a consistent drop off in performance, and the manufacturer provides instructions for changing the belt in the instruction manual. As the standard does not currently address the changing of belts, the manufacturer was allowed to follow internal practice. It should be noted that this is a common laboratory practice among manufacturers and is currently being addressed by the ASTM task group for F608.

Test sample preparation for 40% reduction in suction:

All Unit 3 and Unit 4 samples were prepared for operation at a reduced suction level using the procedure for filled receptacle condition in IEC 60312 - Vacuum cleaners for household use - Methods of measuring the performance. Evaluation of Unit 3 showed that the after meeting the requirements for Conditions 1 and 3 (200 g used), the reduction in suction to

40% had not yet been achieved. Therefore, since this represented the worst-case condition, the manufacturer adjusted all Unit 3 samples to the 40% suction level. For Unit 4, Condition 2 (40% reduction condition) was met prior to Condition 3. A separate restrictor plate was used and adjusted for each sample. For reference, the dirt volume capacities for Units 3 and 4 are 3.69 liters and 2.21 liters respectively. Results of the preparation for operation at 40% reduction in suction are provided in the table.

Restriction Values for Unit 3 and Unit 4 Samples				
	Unit 3			
	Sample 3A	Sample 3B	Sample 3C	Sample 3D
h_i (tube closed)	6.60	6.60	7.16	6.42
h_s (tube open)	6.10	6.00	6.55	5.95
40% h_s - calculated	2.44	2.40	2.62	2.38
40% h_s - measured	2.40	2.38	2.61	2.38
Bag capacity – 3.9 qt = 3.69 liters				
	Unit 4			
	Sample 4A	Sample 4B*	Sample 4C	Sample 4D
h_i (tube closed)	5.22	N/A	5.00	5.52
h_s (tube open)	4.90	N/A	4.70	5.2
40% h_s - calculated	1.96	N/A	1.88	2.08
40% h_s - measured	1.95	N/A	1.87	2.03
Bag capacity – 2.34 qt = 2.21 liters				

* - See sample notes.

Test Room:

The test room is environmentally controlled and maintained at a temperature of $70 \pm 5^\circ\text{F}$ and $50 \pm 5\%$ relative humidity. Environmental conditions were recorded on a chart recorder. Chart recorder sheets are attached. All test samples, carpets and test dirt were conditioned for a period of at least 16 hours in the test room prior to use.

Test Method:

Testing of the subject vacuum cleaners was conducted in accordance with ASTM Specification F608-03, Standard Test Method for Evaluation of Carpet Embedded Dirt Removal Effectiveness of Household/Commercial Vacuum Cleaners. The test dirt conforms to the requirements in ASTM F608.

Reduction in suction was determined using a proposed IEC method for IEC 60312 - Vacuum cleaners for household use – Methods of measuring the performance. A copy of the procedure is attached. The document procedure is detailed in 59F/147/CD - IEC 60312 Ed. 4.0: Vacuum cleaners for household use - Methods of measuring the performance - Reduction in maximum air flow with partly filled dust receptacle. Each unit was evaluated individually and had a separate restrictor plate.

Test Results:

Test data sheets were prepared in an Excel spreadsheet, and signed data sheets for each model cleaner are attached. The test results contained in this report are provided for evaluation by The Hoover Company. No opinions or conclusions are provided by Compliance Consulting Inc.

Miscellaneous:

Additional sand was required for testing. Sieved sand from bag No. 26 was used. The sieve analysis is included with this report.

Units 1 and 2 exhibited problems where the floating nozzle base developed a tendency to bind after a number of test runs. This appeared to affect the results, and extra care was used during the cleaning to minimize the problem. In addition, there was a wide-spread variation in Unit 1. This spread, after testing of eight separate units, was such that it became unlikely that the 90% confidence level would be met. Therefore, after much discussion, a decision was made to use the three samples that yielded the highest cleaning effectiveness.

Unit 5B was replaced due to low performance. An examination of the sample revealed that one of the bottom plate seals was missing. The sample was returned to the store and replaced with a new sample.

An error was discovered in a valve during preparation of sample 4D. Because of this discovery, the test results for samples 4A and 4C were deemed invalid. The two units were evaluated and reset for the 40% reduction, then retested.

Cleaning Test Summary Data

	Plush	Multilevel	Shag	Level Loop	GM	vs Unit 1	vs Unit 2	vs Unit 5
1A	43.97	20.57	7.57	67.90	26.11			
1B	44.70	22.17	7.17	71.23	26.67			
1C	44.70	22.70	6.80	70.07	26.37			
1D		18.40	6.30		10.77			
1E		21.33	7.77		12.87			
1F	44.10	27.60	7.67	72.40	28.67			
1G	43.97	24.50	7.93	70.83	27.89			
1H	45.13	25.47	8.13	71.13	28.55			
Average	44.40	25.86	7.91	71.45	28.37	100%	103%	108%
S	0.64	1.59	0.23	0.83	0.42			
A	2.220	1.290	0.400	3.570	1.420			
ts/sqrt(n)	0.840	1.750	0.250	1.080	0.460			
90% Conf Check	Pass	Fail	Pass	Pass	Pass			
2A	43.70	24.43	7.63	68.00	27.28			
2C	45.73	23.20	7.97	69.23	27.66			
2D	44.33	25.17	7.90	68.90	27.92			
2E	42.13	23.43	8.03					
Average	43.97	24.06	7.88	69.07	27.55	97%	100%	105%
S	1.49	0.91	0.18	0.23	0.32			
A	2.199	1.203	0.394	3.454	1.38			
ts/sqrt(n)	1.753	1.071	0.212	1.027	0.54			
90% Conf Check	Pass	Pass	Pass	Pass	Pass			
3A	61.43	45.60	9.90	70.60	37.41			
3B			10.93					
3C	62.40	47.30	9.47	72.33	37.71			
3D	63.40	50.57	10.23	73.37	39.39			
Average	62.41	47.82	10.13	72.10	38.42	135%	139%	147%
S	0.99	2.53	0.62	1.40	1.07			
A	3.121	2.391	0.507	3.605	1.92			
ts/sqrt(n)	1.669	4.265	0.730	2.360	1.80			
90% Conf Check	Pass	Fail	Fail	Pass	Pass			

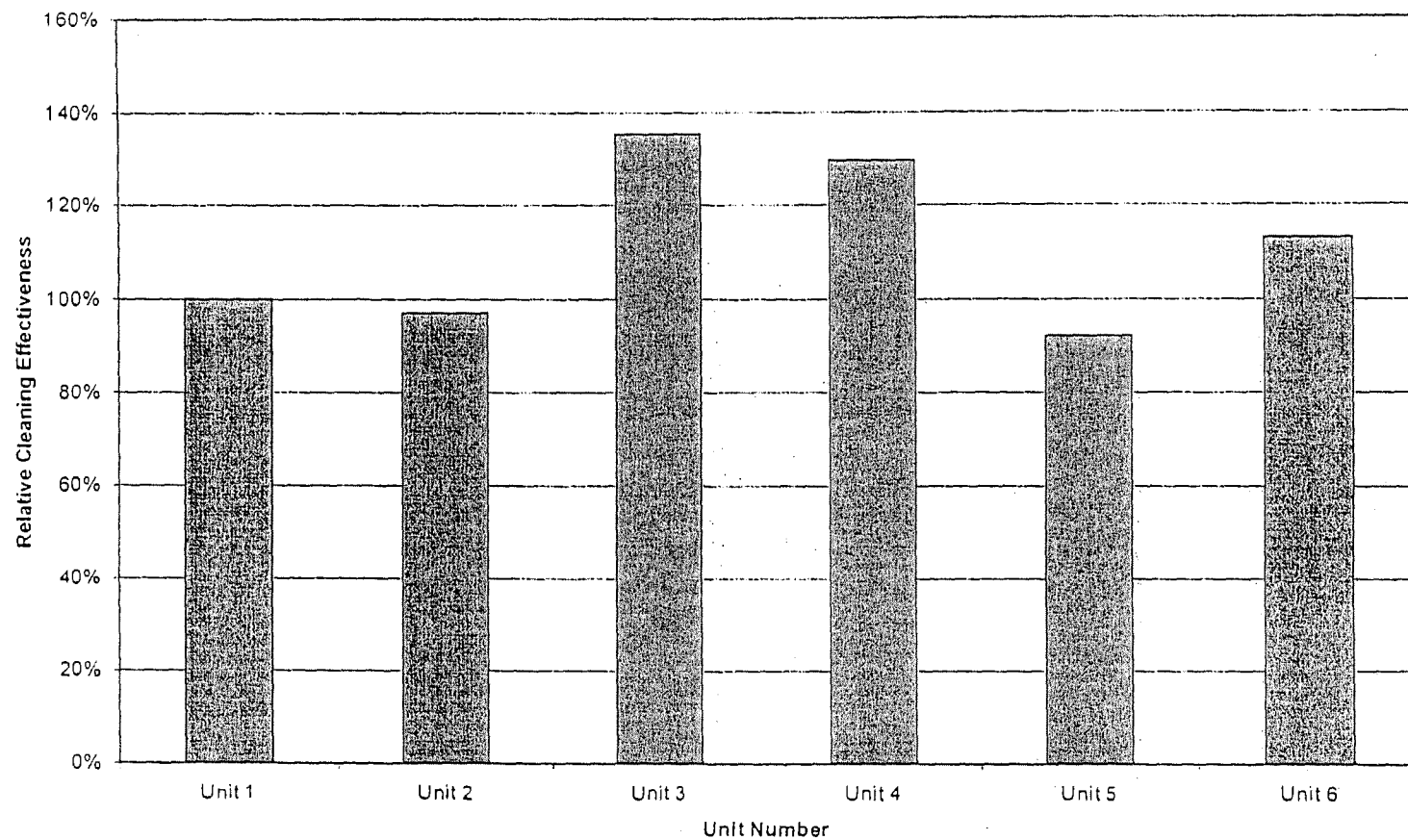
Cleaning Test Summary Data

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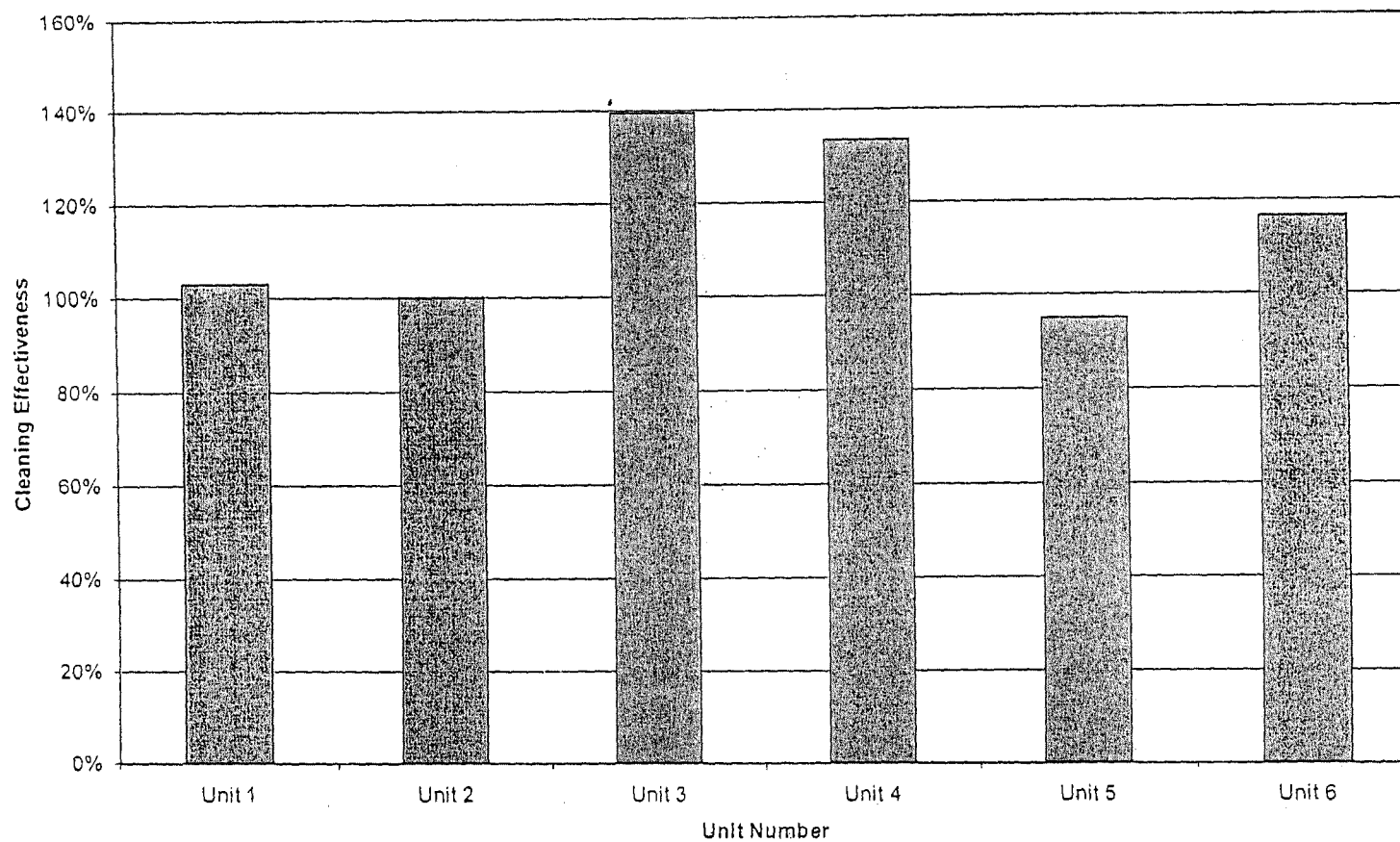
Unit Summary

Unit No.	Plush	Multilevel	Shag	Level Loop	GM	vs DC14	vs DC07	vs DC15
Unit 1	44.40	25.86	7.91	71.45	28.37	100.0%	103.0%	108.4%
Unit 2	43.97	24.06	7.88	69.07	27.55	97.1%	100.0%	105.2%
Unit 3	62.41	47.82	10.13	72.10	38.42	135.4%	139.5%	146.8%
Unit 4	60.40	45.17	9.44	70.88	36.76	129.6%	133.4%	140.4%
Unit 5	46.87	23.46	6.44	66.37	26.18	92.3%	95.0%	100.0%
Unit 6	48.71	36.56	8.53	69.54	32.06	113.0%	116.4%	122.5%

Cleaning Effectiveness Relative to Unit 1



Cleaning Effectiveness Relative to Unit 2



Cleaning Effectiveness Relative to Unit 5

